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Ranking of Important Indicators of Blockchain Technology for the Vegetable Oil Supply Chain

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Abstract

There are four interconnected markets, i.e. oilseeds, crude oil, meal and edible oil, in the vegetable oil supply chain. Nowadays, emerging tools in context of information and communication technologies (ICTs) have critical role to develop the supply chain. The purpose of this study is to identify and prioritize actors' preferences for using blockchain technology in the vegetable oil supply chain. For this purpose, we applied the Analytical Hierarchy Process (AHP) method. We interviewed 15 experts, including scientific specialists from adjacent fields and actors in the vegetable oil supply chain, in 2021, to determine the weight of the pairwise comparison matrix. This study evaluated the leading indicators of management improvement, performance improvement, data security, transparency, traceability and visibility, as well as their sub-indicators. The calculation of final weight revealed the most relevance of sub-indices, i.e. increasing inter-organizational trust, compatibility and secure data compatibility, with value of 0.467, 0.043 and 0.043, respectively. The rest of the indicators were also ranked as data immutability, close relationship with suppliers, degree of privacy, forecasting, strategic planning capabilities, reduction of lead time and doing the order on time, respectively. The lack of trust between circles and actors is thus the most crucial obstacle and the largest potential for the new chain in the current supply chain. More training and knowledge of supply chain players on emerging technologies should be put on the agenda to achieve optimal supply chain management. Our results also suggested solutions for advocating for the planning and development of the required infrastructure for the implementation of blockchain technology in Iran.

Keywords: Multi-criteria decision making, Transparency, Traceability, Visibility.

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Introduction

In recent years, Iran's food industry has grown to become one of the country's most important industries, with a unique position in the country's development and progress. This industry has a better competitive position compared to other industries in the country (Hosseini and Shekhi, 2012). Meanwhile, the food processing industry uses vegetable oil and incorporates it into other food businesses, contributing significantly to Iranian household consumption (OECD, 2017). Oilseeds, crude oil, meal, and edible oil are all interconnected markets in the vegetable oil supply chain. Oilseeds are the first link in the chain, providing the raw materials for the loops that follow. Soybean, rapeseed, and sunflower products are the most major sources of oil among the available oilseeds (Amjadi *et al*., 2012; Dehshiri and Yavari, 2007; Fehrestisani, 2015). Consequently, oil seed production in the country has expanded from around 342 thousand tons in 2001 to over 500 thousand tons in 2020 (Iranian oilseed extraction industry association, 2021).The oil mill, which extracts crude oil from oilseeds, is the second link in the chain. The chain's main output is crude oil, whereas meals are considered a by-product. Because of its usage in animal, poultry, and marine nutrition, as well as plant protein, meal is absolutely critical. Vegetable oil factories are the next link in the chain. In general, the amount of vegetable oil production in the country by oil mills in 2019 was about 1.5 million tons, which in 2020 has been reduced. According to the latest numbers issued by the Ministry of Industry, Mines and Trade, vegetable oil production in the first seven months of this year was over 800 thousand tons, a 20% decline from the same period last year.

It should be mentioned that a considerable portion of oilseeds and crude oil is imported each year to supply the huge demand for vegetable oil. According to import and domestic production statistics, imports account for more than 80% of domestic oil demand (Iran Customs statistics, 2014). In 2019, crude oil imports are expected to be around 2 million tons. In addition, 2.5 million tons of oilseeds were imported this year (Iranian oilseed extraction industry association, 2021). The investigation of the vegetable oil supply chain reveals that, like other agricultural supply chains, it contains multiple loops and stakeholders, as well as complicated conditions. It may be claimed that the supply chain has transformed from a traditional network of manufacturers and suppliers to a complex system of products handled by multiple departments, and coordination among actors is critical (Aste *et al*., 2017). As a result, validating various critical criteria, such as product development phases, quality standards compliance, and monitoring the efficiency of the vegetable oil supply chain, is difficult (Salah *et al*., 2019).

Industries are looking for innovative solutions that promote efficient communication and coordination inside and between different organizations to optimize supply chain management and address existing problems (Farooq and O'Brien, 2012; Williamson *et al*., 2004). Incorporating current technologies into the vegetable oil supply chain can help organizations gain a better understanding of their operations and hence gain more control. Any company's primary goal is to maximize customers' satisfaction and retention. This can only be accomplished if they have a supply chain that is efficient, dependable, and transparent. As a result, it's critical to identify and select the right technology with these qualities (Awwad *et al*., 2018). Blockchain technology has recently been examined in several parts of supply chain and operations management, among the various digital technologies (Ivanov *et al*., 2019; Kshetri, 2018; Oliveira and Handfield, 2019). The supply chain can benefit from blockchain because it allows for more transparent, accuracy, and reliability in transactions across the process (Pilkington, 2016). Bitcoin, a digital cryptocurrency that works without the use of a trusted intermediate, was created by Satoshi Nakamoto (2008), who developed the basic concepts of Blockchain. A blockchain is a database that is created and maintained by a network of peer-to-peer (P2P) members (Wu *et al*., 2019; Yu and He, 2019). In essence, it is a one-of-a-kind database system that is produced, duplicated, synced, and maintained by all decentralized network participants (Zhang, 2019).

A blockchain is a data structure that encrypts each transaction, records it in a data block, and links them together in a chain structure using sophisticated cryptographic methods. Multiple distribution points are also used to register and update data blocks, as well as unique encryption methods to assure data block security (Xie and Li, 2021). According to observations, the most common application of Blockchain has been in the financial sector (Attaran and Gunasekaran, 2019;

Feng *et al*., 2019). However, we may point to broader applications in other areas, including the supply chain, due to the measurements, immutability, and comprehensiveness of this technology and the financial field. Supply chain transactions are highly problematic. Tracking items from raw sources to consumers is one of these issues. It is critical to be able to track customer service and plan and forecast business operations. Furthermore, in supply chain management, stakeholder trust is vital, and an effective supply chain network should be established on it (Tyndall *et al*., 1998). However, supply chain distrust has led network stakeholders to use intermediaries to conduct transactions, which significantly increases operating costs and reduces process efficiency (Poirier, 1999). The lack of transparency in the traditional supply chain is another issue. The extent to which participants have a common understanding and access to correct and sufficient information about products is referred to as supply chain transparency (Deimel *et al*., 2008; Pant *et al*., 2015). However, discrete data in current supply chain networks provide the least transparency. By moving products and data from one agent to another, most of the valuable information is lost. Lack of transparency can also be due to inconsistent data sharing, reliance on paper documents, and inadequate interoperability. In addition to the challenges mentioned, it can be stated that today's supply chain cannot manage risk, reduce costs or meet market needs with rapid change (Chang *et al*., 2020). Blockchain can solve many problems and issues in the supply chain. This system is an innovative technology that improves customer service and increases operational productivity (Agarwal, 2018). In addition, it allows distrustful or unfamiliar stakeholders to review shared information. The nature of blockchain technology relies on three basic principles: decentralization, cryptography, and consensus. A combination of these principles makes it possible to create an editable database. This technology acts as a book for fast transactions and provides trust in a system of unknown users (Friedlmaier *et al*., 2018). In short, blockchain technology speeds up transactions, simplifies the process, increases transparency, reduces waste, and ultimately reduces costs (Wasserman, 2016; Williamson, 1979). Despite the potential role of blockchain technology integrated ICTs in the agri-food supply chain, its use in Iran faces many challenges, an important part of which goes back to the required infrastructure. Items such as internet coverage and speed, crypto currency, and the spread of e-banking are in this group. The next challenge is the laws and policies that need to be developed by the legislature and the executive. The third challenge is its acceptance by current supply chain actors. The first and second challenges can be solved with the help of the experience of leading countries, so-called exogenously. But the third challenge is endogenous. This study was conducted to analyze the third challenge. There is a significant knowledge gap between the blockchain technology adoption and emerging ICTs available. It is yet unknown how actors assess the relative importance of various criteria for technology adoption or how such factors influence their adoption-intention decision processes (Saurabh and Dey, 2020). The existing research, in particular, clarifies the possible design and mechanisms of blockchain technology architecture in agri-food supply chain management. Despite this, it has paid little attention to the preferences of supply chain actors for blockchain adoption. It is necessary to determine the important features of the agri-based supply chain, as well as the ideal mix of this restricted number of attributes that are most authoritative on supply chain users' choice or decision-making.

Review of Literature

Among the studies related to Blockchain, we can mention Esmaeili and Rjabzadeghotermi's study (2019), which identified some of the challenges of adopting blockchain technology in supply chain management and divided them into four groups: organizational, inter-organizational, external, and classification technology. Their study emphasized the need to pay attention to the relationships between supply chain partners when adopting this technology. In another study, Abdullahi and Zoghi (2019) examined the strengths of Blockchain and its role in reducing supply chain management challenges. The results of their research showed that Blockchain improves supply chain traceability and reduces financial and operational risks. Other studies related to the study of blockchain structure include the study of Shahbazi *et al*. (2020), which, while introducing consensus algorithms, expressed their characteristics and compared them. Consensus algorithms specify the rules and protocols by which network members agree on how to add an information block to an information chain. Jouybar and Ebadi (2020) also examined the possibility of using Blockchain in the insurance industry. The study of blockchain capabilities showed that this system could play a significant role by increasing accuracy and speed in the process of acceptance, issuance, and damages and promoting public confidence in the industry.Also, considering the importance of the vegetable oil supply chain, studies examined the issues raised in different links of this chain. Fehrestisani *et al.* (2015) evaluated the capabilities of oil-producing provinces, crude oil extraction units, and edible crude oil refining units. They used the data envelopment analysis method. Based on the results, there is a potential to increase production in the first and second levels of the vegetable oil supply chain. Feyzi (2018) also created a mathematical model for edible crude oil transportation and storage in order to reduce crude oil distribution and storage expenses. Zamani *et al.* (2021) used the multi-market partial equilibrium approach to investigate the import tariff policy along the vegetable oil supply chain. Dehghan *et al.* (2021) designed a closed-loop supply chain network in the edible oil industry using a robust possibilistic-random programming model. Nayak and Dhaigude (2019), who proposed a conceptual model of sustainable supply chain management (SSCM) in small and medium companies (SME) using blockchain technology, are among the foreign research connected to the identification of blockchain features in the supply chain .The conceptual model was developed using multiple-criteria decision-making (MCDM). Various administrative and theoretical implications have been examined, as well as the scope for further research. Competitive dynamics, culture, and financial restrictions, they claim, drive a long-term supply chain employing blockchain technology. Kamble *et al.* (2020) used the Interpretative Structural Modeling (ISM) and Decision-making Trial and Evaluation Laboratory to identify and evaluate thirteen effective variables, including traceability, retrievability, and immutability (DEMATEL). Traceability, auditability, immutability, and provenance were identified as key drivers. These factors are classified according to their driving power and their dependency on power values. Using a rating-based conjoint analysis. Sauraw and Dey (2020) use rank-based symmetric analysis to look at the grape juice supply chain and consider numerous potential drivers for blockchain technology acceptability, including traceability, reduction of intermediaries, transparency, coordination and control factor, adaption factor, and price. Identification and ranking them also proposed a blockchain network structure based on the collected results. To address the issue of information system structure flexibility and reusability, they developed an information system structure with basic supply chain performance requirements in this study. Furthermore, some studies have examined the opportunities and challenges of Blockchain regarding food traceability (Galvez *et al.*, 2018; Kamilaris *et al.*, 2019; Tse *et al.*, 2017). Other studies examined the reliability of the tracking system (Mao *et al.*, 2018; Wang, 2019). Despite the importance of the topic and the high capability of blockchain technology in the agricultural supply chain, very few studies have been conducted, according to a review of the studies. As a result, the current study identifies the key features of blockchain technology that are taken into account by the actors in the vegetable oil supply chain when configuring it.

Materials and Methods

Multi-criteria decision-making techniques (MCDM)

Decision-making can be considered as one of the most critical challenges for experts and analysts for solving various problems. Thus, different methods and algorithms have been proposed in recent decades to support decision-making (Rajabi *et al.*, 2011). Evaluating important quantitative and qualitative indicators of Blockchain is also a strategic decision which such indicators affect directly the decision-making process. Multi-criteria decision-making techniques (MCDM) are the most common methods for dealing with such problems (Çifçi and Büyüközkan, 2011). There are several methods applied in MCDM such as Analytic Hierarchy Process (AHP), Network Analysis Process (ANP), Vikor and TOPSIS. AHP introduced by Saaty (1977) is one of the most popular multi-criteria decision-making methods. This method is applicable when the decision-making action is faced with several competing options (Khaleghi and Mohammadpourzarandi, 2021). The ability to consider quality of criteria, weighting algorithm of standards and simplicity are the main advantages of this method (Dianti Deilami *et al.*, 2011).

Decision-making based on pairwise comparisons is the basis of the AHP approach as a multi-criteria decision-making method (Khaleghi and Mohammadpourzarandi, 2021). This means it compares pairwise criteria to rank priorities for different options (Saaty and Vargas, 1991). Experts should therefore offer numerical values to the prioritization or relative importance of one indicator over another. According to Saaty and Vegas (1991), a range of numerical values from 1 to 9 was provided to compare the criteria representing the degree of importance of each criterion. For more details, the number of 1 implies equal importance, whereas a value of 9 shows that one indicator is more important than another (Saaty and Vargas, 1991). In fact, these scales determine the weight of each factor in terms of competing options (Khaleghi and Mohammadpourzarandi, 2021).

The Analytical Hierarchy Process (AHP)

Therefore, to determine the indicators of blockchain technology for the vegetable oil supply chain and identify the problems, we interviewed faculty members in Industrial Engineering and Food Industry Engineering and actors who were familiar in the vegetable oil market. In the next step, the weight of each criteria and sub-criteria is calculated. By reviewing the studies performed on this technology, we determined six main criteria and associated sub-criteria of the blockchain structure that can be used to configure the vegetable oil supply chain. Figure 1 shows the specified criteria and sub-criteria. The explanation and logic of the main features are as follows:

Criterion 1: Improving supply chain management

Supply chain management is recognized as a fundamental principle for creating a sustainable competitive advantage in the market (Feyzi, 2018). In addition to improving the quality of products and services, it seeks ways to reduce the product production cycle and provides services for reaching the prodict by customer (Zamani *et al.*, 2021). Here the latest advances in science and technology can be utilized. Blockchain technology can create close relationships with suppliers and customers, just-in-time, strategic planning capabilities, coverage of multiple suppliers, outsourcing capabilities, e-commerce capabilities and the ability to integrate chain activities (Saberi *et al.*, 2019; Saurabh and Dey, 2020; Tönnissen and Teuteberg, 2020; Zhang, 2019).

Criterion 2: Improving supply chain performance

Proper supply chain performance plays a key role in the success of an organization and the sustainable achievement of its goals, especially its profitability (Manavizade, 2006). Features of blockchain technology are: to improve performance, reduce lead time, compatibility, forecast, cost savings, resource inventory planning and reduce inventory levels (Hong *et al.*, 2018; Saurabh and Dey, 2020).

Criterion 3: Data Security in the supply chain

Blockchain technology uses asymmetric encryption and digital signature algorithms to ensure data security and individual identity (Zhang, 2019). Once a block with a set of transactions is approved and stored by consensus, the enclosed data can no longer be modified. Therefore, blockchain technology provides a platform for secure data compatibility, data immutability, level of privacy and increased inter-organizational trust (Kamble *et al.*, 2020; Xie and Li, 2021; Zhang, 2019).

Criterion 4: Supply chain transparency

Supply chain transparency is a socio-technical factor that can be enhanced or ensured through the immutability of transactions onto the distributed architecture of Blockchain (Pant *et al.*, 2015). The blockchain consensus algorithm allows supply chain actors to identify process risks and improve supply chain performance and transaction reliability (Saurabh and Dey, 2020; Zhang, 2019).

Criterion 5: Supply chain traceability

Supply chain traceability is a critical quality factor that can be augmented by applying Blockchain and other existing technologies, such as Internet of Things (IoT). The choice or adoption of integrated blockchain technologies is attributed to an electronic traceability system that has gained salience as a risk management tool to ensure food safety, food quality, and chain integrity (Pappa *et al.*, 2018, Saurabh and Dey, 2020).

Criterion 6: Supply Chain visibility

Blockchain-based supply chain transactions provide a reliable mechanism for managing identity (Alam, 2016), allowing access to time, location, and other data in any action on the product in the supply chain. All data is synchronized with all stakeholders in real-time, which increases the trust of actors in the supply chain network (Zhang, 2019).

For this purpose, there are different methods, including the least-squares method, logarithmic squared method, Eigen vector method, and approximate methods (Ghodsipour, 2002). In the present study, the arithmetic means method, one of the approximate methods, has been used, which is expressed as Equation (1):

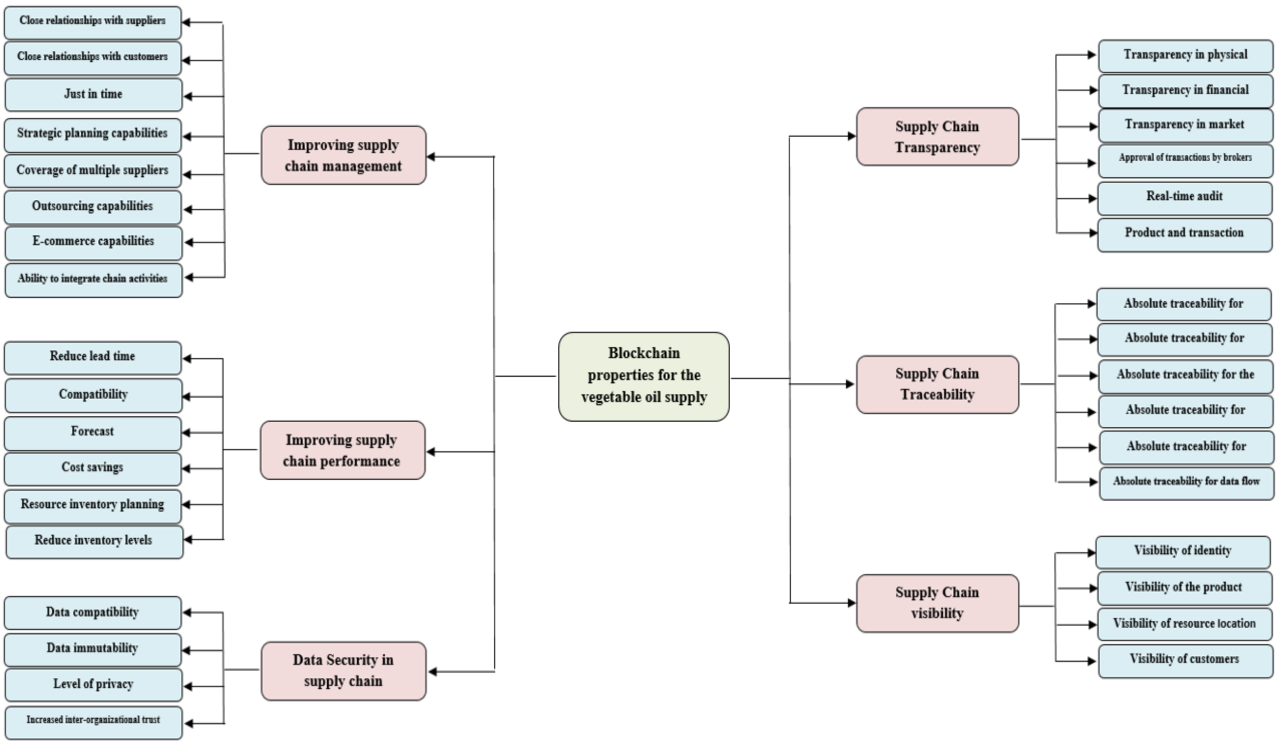

Figure 1- Blockchain technology indicators for configuration of vegetable oil supply chain

$$E_{ij} = \frac{e_{ij}}{Y_j} \quad (1)$$

$$w_i = \frac{\sum_{i=1}^{n} E_{ij}}{n} \quad (2)$$

Where E_{ij} represents the normalized matrix components ande_{ij}, which represents the first pairwise comparisons.Y_j is the sum of the columns of the matrix. In this method, the matrix must first be normalized, for which purpose the matrix elements are divided into their column set. Then, to calculate the weight, the line means of the normalized matrix must be estimated, which is shown in Equation (2)by w_i(Delbari and Davoodi, 2012). But in this method, the validity of the respondents' answers to pairwise comparisons should be examined (Delbari and Davoodi, 2012). The preferences and tastes of different people are contradictory. The dependence of this method on analysts' opinions may cause confusion and deviation in calculations and errors and inconsistencies in comparing and determining the importance of options (Rajabi *et al.*, 2011). Thus, Saaty (1977) introduced the mechanism by which the validity of the even matrix is measured. This method determines the incompatibility rate to check the robustness of the pairwise comparison matrix. Incompatibility rate (CR) The ratio of the incompatibility index (CI) to the random index (RI) is defined, which can be shown as Equation (3):

$$CR = \frac{CI}{RI} \quad (3)$$

Saaty (1977) calculated the random index (RI) as the mean strength of square matrices of different orders, quantified by entirely random values. Therefore, this index is predetermined. The value of the incompatibility index will be prioritized directly from the matrix and will be calculated using Equation (Alam, 2016):

$$CI = \alpha_{max} - \frac{n}{n-1} \quad (4)$$

where, α_max represents the largest eigenvalue of the pairwise comparison matrix and n is the order of the matrix. According to the Saaty and Vargas (1991) study, if the degree of incompatibility of the matrices is less than or equal to 0.1, the judgments are stable, and the comparison matrix does not need to be revised (Saaty and Vargas, 1991). Finally, AHP logic combines matrices from pairwise comparisons to calculate the final weight (Khaleghi and

Mohammadpourzarandi, 2021). In a hierarchical process, the final weight of the sub-criteria is determined by the sum of the product of the importance of the criteria in the weight of the sub-criteria (Delbari and Davoodi, 2021).

Data gathering

Accordingly, in the present study, to determine the weight of the pairwise comparison matrix, 15 experts who specialized in the fields of industrial engineering, food industry engineering and agricultural economics were interviewed through completing a questionnaire.

Results and Discussion

The goal of this research was to identify and prioritize the most important blockchain indicators for configuring the vegetable oil supply chain. For this purpose, the AHP method was used. According to the method, after determining the criteria and sub-criteria and creating a hierarchical structure, the matrix of pairwise comparisons was formed and completed by experts. The relative weight of each criteria and sub-criteria was computed using the arithmetic mean approach after completing the questionnaire and identifying the priorities (Abdipour and Alavian, 2017). Table 1 summarizes the findings.

Table 1- Relative weight of blockchain technology indicators for configuration of vegetable oil supply chain

	Code	Management	Code	Performance	Code	Security	Code	Transparency	Code	Traceability	Code	Visible
1	w_{11}	0.172	w_{21}	0.179	w_{31}	0.252	w_{41}	0.224	w_{51}	0.193	w_{61}	0.224
2	w_{12}	0.136	w_{22}	0.216	w_{32}	0.24	w_{42}	0.192	w_{52}	0.15	w_{62}	0.304
3	w_{13}	0.145	w_{23}	0.196	w_{33}	0.232	w_{43}	0.149	w_{53}	0.165	w_{63}	0.3
4	w_{14}	0.16	w_{24}	0.129	w_{34}	0.275	w_{44}	0.12	w_{54}	0.185	w_{64}	0.171
5	w_{15}	0.082	w_{25}	0.169			w_{45}	0.14	w_{55}	0.149		
6	w_{16}	0.068	w_{26}	0.109			w_{46}	0.173	w_{56}	0.156		
7	w_{17}	0.138										
8	w_{18}	0.095										

Source: Research Findings

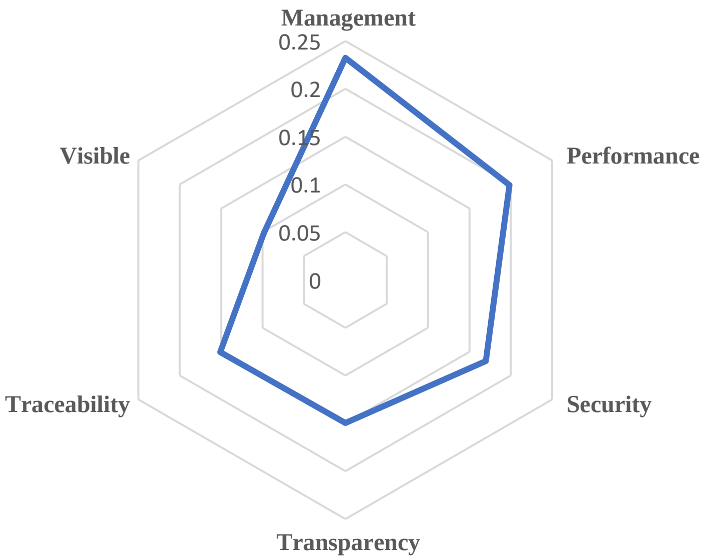

Figure 2- Weight of the main criteria

According to the findings, the criteria of improving management and improving the performance of the vegetable oil supply chain are respectively the most important among the main criteria, as shown in Figure 2. In addition, supply chain visibility was ranked lower than other criteria. The incompatibility rate is calculated in this method to determine the validity of the responses. Equations (3) and (4) were used to calculate the incompatibility rate for each paired comparison matrix in each questionnaire sample in this study. The incompatibility rate for all matrices is less than 0.1, according to the results (Table 2).

Finally, as shown in Table 2, the final weight of each sub-criteria was calculated. The sub-criteria can also be classified in Figure 2 based on the estimated final weight.

The sub-criteria of "increasing inter-organizational trust" with a weight of 0.068 had the most importance among the 34 sub-criteria, according to the results shown in Table 3 and Figure 3. Organizational performance and shaping and improving organizational efficiency are intimately connected. There is no way to achieve strategic goals without trust. Lack of confidence between supply chain brokers will lead to an instability in the supply chain (1, 25). Mohammadjafari *et al*. (2015) also stated that trust is one of the determining factors in the relationship between industrial buyers and suppliers (Mohammadjafari *et al.*, 2015).Therefore, considering that the main features of blockchain technology are transparency, high security, and traceability, it can be said that such features will increase inter-organizational trust. Also, the sub-criteria of "compatibility", "secure data compatibility", "data immutability" and "close relationship with suppliers" were in the second to fifth ranks with, respectively. Compatibility means adapting chain activities to market needs. Supply chain management seeks to increase adaptability and flexibility to respond quickly and effectively to market changes. Therefore, adapting chain activities to market needs can improve performance of the supply chain. Secure data compatibility and data immutability are sub-criteria of data security in the supply chain. Data security is the rapid and constant updating of data and the verification of data by various offices in terms of secure data compatibility. To data immutability, i.e. hacking or forgery, as mentioned, each block contains its hash function, i.e. a unique fingerprint, and the hash of the previous block, which must be recalculated with each change in the block. This feature results in very high data security in blockchain technology. Validation is managed by a central authority in traditional data management systems, which is often hacked and manipulated. Nevertheless, there is no need for the central authority to confirm the user's authorizations in blockchain technology, and all users and members of the P2P network, by adding an agreement, approve new items added to the blockchain, making data manipulation very difficult. A blockchain ensures that each user recovers data correctly and unchanged as the information is recorded.

Table 2- Consistency test of the pairwise comparison matrix

Code	α_{max}	n	CI	RI	CR	Consistency
m_1	8.139	8	0.019	1.41	0.1<0.014	Yes
m_2	6.059	6	0.01	1.24	0.1<0.008	Yes
m_3	4.008	4	0.002	0.9	0.1<0.003	Yes
m_4	6.053	6	0.01	1.24	0.1<0.008	Yes
m_5	6.036	6	0.007	1.24	0.1<0.005	Yes
m_6	4.018	4	0.006	0.9	0.1<0.006	Yes

Source: Research Findings

Table 3- Final weight of blockchain technology indicators for configuration of vegetable oil supply chain

Code	Management	Code	Performance	Code	Security	Code	Transparency	Code	Traceability	Code	Visible
$w_{f_{11}}$	0.04	$w_{f_{21}}$	0.035	$w_{f_{31}}$	0.042	$w_{f_{41}}$	0.033	$w_{f_{51}}$	0.029	$w_{f_{61}}$	0.022
$w_{f_{12}}$	0.031	$w_{f_{22}}$	0.042	$w_{f_{32}}$	0.04	$w_{f_{42}}$	0.028	$w_{f_{52}}$	0.022	$w_{f_{62}}$	0.030
$w_{f_{13}}$	0.033	$w_{f_{23}}$	0.039	$w_{f_{33}}$	0.039	$w_{f_{43}}$	0.022	$w_{f_{53}}$	0.024	$w_{f_{63}}$	0.029
$w_{f_{14}}$	0.037	$w_{f_{24}}$	0.025	$w_{f_{34}}$	0.046	$w_{f_{44}}$	0.017	$w_{f_{54}}$	0.028	$w_{f_{64}}$	0.016
$w_{f_{15}}$	0.019	$w_{f_{25}}$	0.033			$w_{f_{45}}$	0.021	$w_{f_{55}}$	0.022		
$w_{f_{16}}$	0.015	$w_{f_{26}}$	0.021			$w_{f_{46}}$	0.025	$w_{f_{56}}$	0.023		
$w_{f_{17}}$	0.032										
$w_{f_{18}}$	0.022										

Source: Research Findings

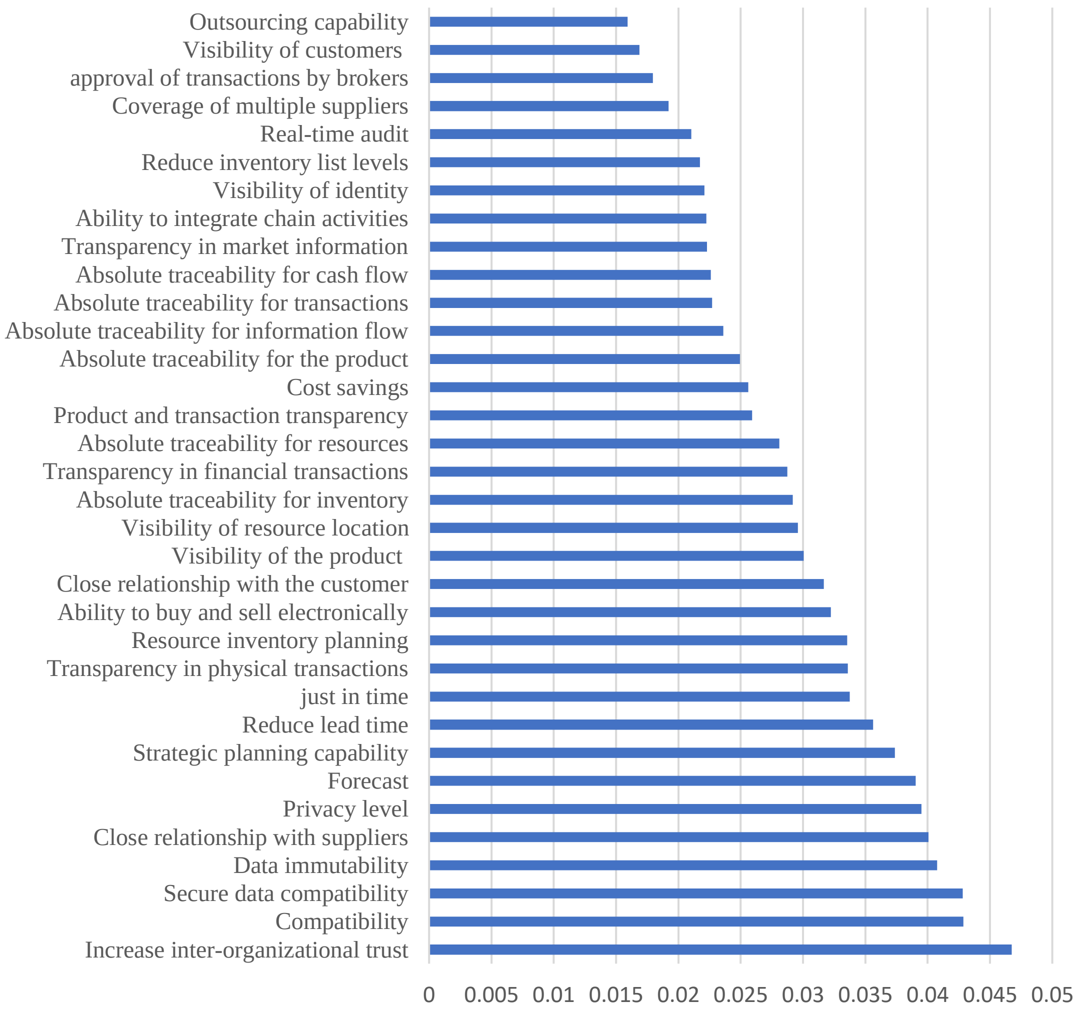

Figure 3- Ranking of blockchain technology indicators for configuration for vegetable oil supply chain

Then, the new transaction is validated and the transaction is written. A transaction alters the information contained in the block, which occurs due to the transfer of assets between a seller and a buyer. Inputting a set of new data to the blockchain does not make a distortion in pervious data. After validation, miners broadcast the new, unchangeable block to the entire P2P network. In the last stage, actual information about the contractual status and transaction tracing using internet capacity is done. The integration of different organizations that can interact with each other and share digital assets with each other continuously is facilitated. Fundamentally, interoperability is improved by this module and assists in building more partnerships among various organizations and driving better business value with common blockchain solutions (Ghode *et al.*, 2020). Another important indicator is the close relationship with suppliers. This index allows each link to connect with its previous links in the supply chain. Suppliers can have a huge impact on the performance of companies in terms of price, quality, technology and delivery. Ghafaritouran (2007) stated in his study that new and important approaches that have been proposed in supply chain management could lead to strengthening and expanding relationships with suppliers in the organization in the form of a supplier relationship management system (Ghafaritouran, 2007). Supplier Relationship Management, which considers the entire supply chain from the supply of raw materials to the final consumer to increase customer satisfaction and reduce costs. Other important indicators include level of privacy protection of individuals' identity through encryption, forecasting, strategic planning capability or long-term planning to attract investment, Financing, providing input and selling the product, reducing lead time "and"just-in-time".

Conclusions

The current study aims to identify and rank Blockchain technology indicators that performed to configure the vegetable oil supply chain, taking into account the potential role of blockchain technology as well as integrated information and communication technology in the food supply chain, as well as the need to identify the preferences of vegetable oil supply chain actors in order to design a blockchain structure for this chain. The AHP approach, which is one of the MCDM methods, was employed for this. This strategy aids in the simultaneous identification of the best solution among a variety of decision criteria. The proposed framework has been done using survey data collected from two sources, including scientific experts from various academic disciplines and vegetable oil supply chain actors. The results of calculating the weight of each of the sub-criteria showed that "increase in inter-organizational trust", "compatibility", "compatibility of secure data", "data invariance", "close relationship with suppliers"," The level of privacy", "forecast", "strategic planning capability", " reduce lead time " and " just-in-time" have the highest weight and importance, respectively. The present study can help existing research on Blockchain, especially concerning supply chains, by providing a helpful evaluation model and a quantitative framework to implement blockchain technology. Also, this research has taken a step toward improving the existing conditions in this chain by identifying the current problems in the vegetable oil supply chain, providing a suitable solution, and introducing innovative technology. Furthermore, by designing the structure of this technology according to the preferences of the actors in the supply chain of vegetable oil and the cooperation of the policymakers of this sector, the conditions of this chain can be improved. According to the findings, the supply chain management criteria was critical. To do this, increased training and familiarity of supply chain actors with new technologies and their features should be prioritized in order to move the supply chain away from its existing traditional configuration. It is also recommended that infrastructure be planned and prepared in connection with legal and governance frameworks, building on the experience of other countries to identify infrastructure and executive concerns.

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رتبه‌بندی شاخص‌های مهم فنآوری بلاکچین برای زنجیره تأمین روغن نباتی

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چکیده

زنجیره تأمین روغن نباتی مشتمل بر چهار بازار به هم پیوسته می باشد. این بازارها شامل دانه‌های روغنی، روغن خام، کنجاله و روغن خوراکی می‌باشد. امروزه فناوری اطلاعات و ارتباطات یکپارچه در بهبود زنجیره تأمین نقش انکارناپذیری دارد. پذیرش هر فنآوری جدید بخش مهمی از توسعه آن می‌باشد. هدف از این مطالعه شناسایی و رتبه‌بندی ترجیحات بازیگران زنجیره تأمین روغن نباتی کشور نسبت به ویژگی‌های فنآوری بلاکچین است. به این منظور از روش فرآیند تحلیل سلسله مراتبی (AHP) استفاده شد. برای تعیین وزن ماتریس مقایسات زوجی، با ۱۵ کارشناس متشکل از کارشناسان علمی از رشته‌های مرتبط و همچنین کارگزاران زنجیره تأمین روغن نباتی در سال ۱۴۰۰ مصاحبه انجام گرفت. در این پژوهش، شاخص‌های اصلی بهبود مدیریت، بهبود عملکرد، امنیت داده، شفافیت، ردگیری و پدیداری و زیرشاخص‌های آنها مورد ارزیابی قرار گرفتند. نتایج حاصل از محاسبه وزن نهایی نشان داد که زیرشاخص‌های "افزایش اعتماد بین سازمانی"،"سازگاری"، "سازگاری داده‌های ایمن" به‌ترتیب با وزنی معادل ۰/۴۶۷۰، ۰/۰۴۲۸ و ۰/۰۴۲۸۲ بالاترین اهمیت را داشتند. همچنین شاخص‌های "تغییرناپذیری داده‌ها"، "ارتباط نزدیک با تأمین‌کنندگان"، "سطح حریم خصوصی"، "پیش‌بینی"، "قابلیت برنامه‌ریزی استراتژیک"، "کاهش زمان بازپرسازی" و "انجام به موقع سفارش" به‌ترتیب در رده‌های بعدی قرار گرفتند. به این ترتیب مهمترین چالش در زنجیره عرضه فعلی و بهتزین فرصت برای زنجیره جدید عدم اعتماد بین حلقه‌ها و فعالان می‌باشد. به‌منظور دستیابی به مدیریت بهینه زنجیره تأمین، پیشنهاد می‌شود آموزش و آشنایی بیشتر بازیگران زنجیره تأمین با تکنولوژی‌های جدید و ویژگی‌های آنها در دستور کار قرار گیرد. همچنین برنامه‌ریزی و آماده‌سازی زیرساخت‌های لازم جهت پیاده‌سازی فناوری بلاکچین در کشور پیشنهاد می‌شود.

واژه‌های کلیدی: تصمیم‌گیری چندمعیاره، فنآوری بلاکچین، زنجیره تأمین، روغن نباتی

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